

INTERLEAVED SEQUENCING METHOD FOR  
MULTIPLE TWO-DIMENSIONAL SCANNING CODES

BACKGROUND OF THE INVENTION

Technical Field

This invention relates in general to scanning codes for identifying parts, and in particular to a method for sequencing multiple two-dimensional scanning codes to identify small parts.

Background Art

In the manufacturing of disk drives, it is very important to be able to track spindle motors by their serial number. The serial numbers are used to assure that motors and disks are correctly reworked and ultimately assembled into the disk drive correctly. Some disk drives utilize a flexible printed circuit cable upon which a linear, one-dimensional bar code label can be affixed with pressure sensitive adhesive. The labels contain both human-readable and scanner-readable serial number information.

However, some disk drives use leaf spring connectors that mate to connector pads on the motors instead of using flexible cables. These disk drives have very limited surface area upon which a one-dimensional bar code label may be affixed. The only readily available surface area on these disk drives is their ferrofluid cap on top of the motor. In order to have the serial number encoded, a more compact two-dimensional (2-D) "micro-checkerboard" code, such as a "Data Matrix" symbols, is used (see Figure 1).

Although it is possible to locate the 2-D code and human-readable characters around the cap, it is not advisable to use adhesives to attach a preprinted label to the cap since the cap will rotate at high speeds. Small particles of adhesive could creep out from beneath the labels and fly off into the file. Also, small shards from the label cutting operation could fly off the label and cause contamination failures.

This problem can be overcome by laser etching the 2-D code and human-readable characters onto the cap. This solution can be performed with no contamination exposure. However, with laser etching, the optical contrast and edge sharpness are somewhat lacking compared to conventionally

printed labels. This is due to the fact that 2-D codes contain many very small cells, some of which are etched and some of which are left blank. For example, the minimum permissible array size is a 10x10 code array containing 100 cells. However, a 10x10 array can only encode up to three alphanumeric characters. In order to maximize the scanner read reliability, it is important to keep the individual cells of the 2-D code as large as possible. Larger cells are more impervious to slight dents, scratches and raw material surface imperfections, and laser etching imperfections than small cells.

Unfortunately, the serial numbers of some disk drives contain nine alphanumeric characters. It would take a 14x14 array to encode the entire nine characters in a single array, which is prohibitively large in size to fit on small parts. As shown in Figure 2, one solution is to split the serial number 11 into three array codes 13, 15, 17 of three characters each on the part 19 (i.e. three 10x10 arrays located adjacent to one another). It is noteworthy that, using the same available space, the cells of a 10x10 array are about twice as large as those of a 14x14 array.

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At the beginning of the manufacturing operation, the motor is placed onto a conveyor pallet by an operator without regard to angular orientation. The optical scanner for the 2-D codes views the entire motor cap. The scanner algorithm is capable of reading all three arrays independent of their orientation. However, since there is no predictable angular orientation, the scanner is unable to control the scan sequence. The three arrays must be ordered in the correct sequence so that the nine character serial number can be correctly reconstructed. Thus, a method for assuring the correct sequencing of multiple, randomly read array codes is needed.

#### Summary of the Invention

A component has three, laser etched, two-dimensional arrays that each contain three characters of its nine character, alphanumeric serial number. In order for this concept to work, the first three characters of the serial number must be constant for all parts of this type. As a result, the serial number can be divided among the arrays by using the first character as the first digit in the first array, the second character as the first digit in the second

array, and the third character as the first digit in the third array. The remaining characters of the serial number are interleaved in the arrays in the following pattern: the fourth and fifth characters are the second and third digits in the first array, the sixth and seventh characters are the second and third digits in the second array, and the eighth and ninth characters are the second and third digits in the third array. With this system, the correct sequence for the arrays will always be ascertainable regardless of the order in which they are read.

#### Brief Description of the Drawings

So that the manner in which the features, advantages and objects of the invention, as well as others which will become apparent, are attained and can be understood in more detail, more particular description of the invention briefly summarized above may be had by reference to the embodiment thereof which is illustrated in the appended drawings, which drawings form a part of this specification. It is to be noted, however, that the drawings illustrate only a preferred embodiment of the invention and is therefore not

to be considered limiting of its scope as the invention may admit to other equally effective embodiments.

Figure 1 is an enlarged plan view of two-dimensional, machine-readable code.

Figure 2 is a top view of a part having prior art, simulated, multiple two-dimensional array codes.

Figure 3 is a top view of the part of Figure 1 having a simulated sequence of two-dimensional array codes constructed in accordance with the invention.

Figure 4 is an enlarged top view of the part of Figure 3 having human-readable and machine-readable codes.

#### Best Mode for Carrying Out the Invention

Referring to Figures 3 and 4, an assembly part such as a motor cap 21 with a central axis and three, laser etched array codes 23, 25, 27 on its upper surface for identifying and encoding the nine character, alphanumeric serial number of cap 21. A human-readable code 29 of the serial number is also etched on cap 21. Note that Figure 4 depicts a realistic view of cap 21 with human and machine-readable codes, while Figure 3 is shown for illustration purposes. In the embodiment shown, the array codes 23, 25, 27 are

laser etched on cap 21 and substantially equidistant from the axis.

Fortunately, for a given product program having a nine character alphanumeric serial number, the prefix or first three characters are always constant. The remaining characters are completely unique to cap 21. Thus, the first three or "order" characters can be entered into the system by the operator at the beginning of a production run. Note that the order characters may also comprise other prefixes, suffixes, or the like.

For example, if a serial number is "XYZ1A2B3C", it would normally be split between arrays as follows: "XYZ", "1A2", and "B3C", respectively (like Figure 2). However, if the serial number code is interleaved by taking the first three characters and assigning them as the first digit of each of the arrays 23, 25, 27, their correct sequence will always be ascertainable regardless of the order in which they are read. Thus, the serial number would be split between arrays 23, 25, 27 as follows: "X1A", "Y2B", and "Z3C" (Figure 3). The sequence information is encoded into each array and can be used to reconstruct the correct serial number independent of the scan sequence. Note that in

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Figures 2 and 3, even through the "digits" of the arrays are shown as alphanumeric characters, they would actually be encoded in a machine-readable format (like Figure 4). After cap 21 is encoded, its codes or arrays 23, 25, 27 are scanned or read by a machine code reader to reconstruct its serial number and verify its accuracy.

The invention has several advantages. This encoding method permits the use of multiple, two-dimensional codes on an unoriented axis-symmetric object with normal scanners which are incapable of determining code sequence. It is desirable to maintain simplicity with the normal serial number sequence which increments the low order digits most often, and the high order digits the least. This concept is useful to maximize the readability of the serial number in the presence of dirt, scratches, and contamination. The serial number is divided amongst a plurality of data matrix codes to maximize the size of the individual cells in each matrix.

While the invention has been shown or described in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention. For example, the order characters, unique characters, and array codes could be greater or fewer in number. In addition, the serial number could be sequenced in any programmable order including forward, backward, odds, evens, etc.

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